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CONTENTS

The Effects of Irrigation, Nitrogen Fertilization and Maleic Hydrazide Spray on the Yield, Composition and Storage Behavior of Bulbs of Two Onion Varieties . . . *Andres F. Celestino* 479

The Performance of a Cross-Section Sample of Standard U.S. Double Crosses During One Dry Season in Laguna, Philippines . . . . . *I. S. Santos and I. C. Cagampang* 502

The Acid Constituents of Some Philippine Fruits . . . . . *A. R. Carangal, Jr., L. G. Gonzales, and I. L. Daguman* 514

The Occurrence of Twin Embryos in *Cocos Nucifera* L. . . . . *Virgilio F. Guevara* 520

NOTE:

Wild Species of Rice in the Philippines . . . . . *J. M. Capinpin and J. V. Pancho* 523

Montgomery E. Robinson 525

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THE EFFECTS OF IRRIGATION, NITROGEN FERTILIZATION AND MALEIC HYDRAZIDE SPRAY ON THE YIELD, COMPOSITION AND STORAGE BEHAVIOR OF BULBS OF TWO ONION VARIETIES [1]

ANDRES F. CELESTINO [2]

WITH ONE TEXT FIGURE

A split, split, split-plot design was used to determine the effects of irrigation, nitrogen fertilization, and maleic hydrazide spray on the yield, composition, and storage behavior of two varieties of onions.

Granex yielded more and bigger bulbs than Excel but had more rotting at harvest. Nitrogen increased bulb diameter and yield but also increased field rotting. Greater bulb size response to fertilization was obtained from irrigated than from non-irrigated plots.

During curing, the unfertilized bulbs, irrespective of the other treatments, rotted and lost more weight than the fertilized bulbs. Granex rotted more than Excel.

Excel had greater nitrogen and soluble solid contents but fewer sound bulbs than Granex. Granex, on the other hand, had a greater dry matter and sound bulbs than Excel.

In common storage, rotting accounted for about 88 per cent of the storage losses. The main effect of variety largely influenced these losses. The difference exhibited by the two varieties, however, indicated no practical significance because the amount of sound bulbs left for each variety at the end of the storage period was very small that it would be bankrupt either way. The other treatments did not have any appreciable effect.

In cold storage, sprouting accounted for about 54 per cent while rotting and shrinkage accounted for about 16 per cent only of the total losses in storage. Granex had less sprouting than Excel. The pre-harvest application of maleic hydrazide reduced sprout growth to about half that of the unsprayed bulbs. The interaction effect of V x MH was significant—MH reduced sprouting on Granex more than on Excel. Maleic hydrazide,

[1] Central Experiment Station Contribution No. 2073. This paper is based on the thesis submitted to the Graduate School, U.P., 1960, for the M.Sc. degree.

[2] The author is grateful to Dr. W. C. Kelly for his advice and interest, Mr. J. R. Deanon, Jr. for his help in the conduct of the experiment, Dr. F. F. Campos for her criticisms of the manuscript, Mr. M. M. Ylagan and associates for analyzing the nitrogen content of the onion bulbs, and the ACCFA for giving a grant to the College part of which was used to finance this project.

on the other hand, slightly increased rotting and shrinkage. However, the "decrease-sprouting" effect of the chemical more than offset its "increase-rotting" effect. The other treatments did not have any marked effect.

Both length of storage period and storage location influenced the number of sound, sprouting and rotting bulbs. These differences due to storage location were due largely to moisture differences caused by condensation and dripping and temperature gradients from the top to the bottom of the storage pile.

Onion (*Allium cepa* L.) is grown successfully in the Philippines although its commercial production is restricted to a very definite season, e.g., onions grow well if they become established during the cool months of November to January and then mature in the dry hot months of March to May. Because of the high prices that prevail during the off-season, farmers and other individuals engaged in the handling and marketing of onions store a large part of the bulbs after harvest in open-shaded areas or in cold storages.

The frequent sprouting and rotting in storage is one of the most important problems met in onion culture. Storage behavior might be related to climatic factors and management practices affecting the growth of the plant. It seems logical, then, to study the effects of nitrogen fertilization and irrigation on the storage behavior of onion bulbs and the relation of these factors on the response of onion bulbs to maleic hydrazide spray.

This study centered on the investigation of the effect of nitrogen fertilization, irrigation, and maleic hydrazide spray on the yield, composition, and storage behavior of two varieties of onions. The onions were stored in a cold and in a common storage. The nitrogen content, per cent soluble solids, and per cent dry matter of the bulbs were determined on all lots after harvesting. Storage losses due to sprouting, rotting and shrinkage were determined at monthly intervals throughout the storage period.

The work was done at the Vegetable Crops Division of the Department of Agronomy, U.P. College of Agriculture, from November, 1958 to June, 1960. The analytical work was done at the Central Experiment Station Analytical Laboratory in the Department of Agricultural Chemistry. The bulbs were stored at the NOGROCOMA Cold Storage Plant at Caloocan, Rizal and in the Vegetable Crops Shed House for the common storage.

MATERIALS AND METHODS

Plan of the field experiment

The seeds were sown in outdoor seedbeds fumigated with 1 part formalin (40 per cent) to 5 parts water. The seedlings were transplanted to the experimental field when their bases were about 0.5 centimeters in diameter.

The experimental lot was thoroughly prepared. Six irrigation whole plots each consisting of three nitrogen subplots measuring 1 x 14 meters were laid out. These subplots were raised and smoothed to about four inches high.

The plants were set 15 centimeters apart each way. The onions were mulched with about two inches thick coconut coir after they were transplanted.

Treatments consisted of different levels and combinations of the following:

1. *Irrigation.* Two levels of irrigation were used: (a) irrigated two inches per week until harvest, and (b) rainfall only during (0.51 inch) the last six weeks before harvest. Hereafter, these two treatments will be referred to as irrigated and no irrigation treatments, respectively.

At the outset, all plots received two inches of irrigation water per week until six weeks before harvest, then, one half of the plots were no longer irrigated. Irrigation water was applied with a Perf-0-rain irrigation system. The relative amount of irrigation water applied was measured with 36 graduated cans distributed over the entire experimental area.

In the first week, the two inches of water was applied twice at one inch per application to get a good initial stand of crop. The highest rainfall, 2.44 inches, occurred in the fourth week after planting. No water was applied at this time. The irrigated plants received a total of 25.56 inches of water during the whole growing season of which 22.0 inches came from irrigation water. Non-irrigated plants received only 8 inches of irrigation water (from the time of planting to six weeks before harvest) and 2.59 inches of rainfall. About 0.51 inch of this rainfall occurred during the last six weeks before harvest.

2. *Fertilizer treatment.* Three levels of nitrogen, 0, 60, and 120 kilograms per hectare were used. The nitrogen was applied as urea

(45 per cent N). All the fertilizer was broadcast before planting. No phosphorus and potassium were added.

Analysis of the experimental field before the application of fertilizer showed that it contained 0.152 per cent total nitrogen, 0.014 per cent available P_2O_5, 0.078 per cent available K_2O and a pH of 5.42.

3. *Maleic hydrazide.* Two levels of maleic hydrazide (MH-30), 0 and 2500 parts per million, were used. The plants were sprayed two weeks before harvest. About 70 per cent of the tops had fallen over at this time. Approximately one half gallon of solution was applied per plot of 1 x 14 meters.

4. *Variety.* Two varieties, Excel and Granex Hybrid were used as test varieties. The varieties were planted in alternate rows.

A split, split, split-plot design was used. The 24 treatments were randomized in three replicated blocks. The irrigation treatments were the whole plots, nitrogen levels the first split, and maleic hydrazide, the second. The maleic hydrazide sub-plots were split into varieties.

The onions were harvested when about 90 per cent of the tops have fallen over. The tops were cut and the bulbs were spread thinly in wooden boxes. Curing was done in a well-ventilated room for a period of two weeks.

Analytical procedures

The bulbs were analyzed for soluble solids, dry matter and nitrogen contents after harvest before curing.

Sampling procedure. Three randomly selected bulbs were taken from each treatment. Each sample was sliced longitudinally into equal halves. The halves of each bulb were composited for soluble solids determination.

For the dry matter and nitrogen determinations, another three randomly selected bulbs were used. The halves of each bulb were composited for the analyses.

Methods of analyses. For soluble solids, the samples were chopped into small pieces and placed in cheese cloth bags. The juice was expressed with a vise and collected into a petri-dish. It was placed in the prism of a Bausch and Lomb Hand Refractometer and the reading was taken.

The per cent dry matter and total nitrogen were determined from the same sample. The samples were diced into approximately one cubic centimeter after taking the initial weight and then, dried to constant weights in an electric drying oven maintained at 70°C. Weights were considered constant when the difference between readings for each sample was not more than 0.02 gram. The per cent dry matter was calculated based on the oven-dry weights.

The total nitrogen was determined from the resulting dry matter from oven drying by the standard Semi-micro Kjeldahl procedure.

Plan of the storage experiments

Two conditions of storage were studied. The bulbs in each treatment were divided into two lots — one lot was stored under refrigeration at a temperature ranging from 33 to 36°F and with a relative humidity of 75 to 87 per cent over a period of four months. Common storage was done under room conditions (81-87°F and a relative humidity ranging from 62 to 84 per cent).

The bulbs were put in 24 x 15 x 7 inches wooden crates with four compartments. Each crate corresponds to one nitrogen subplot which consisted of 4 sub-treatments (two levels of MH on two varieties). The crates were piled inside the storage by replication: replication I at the bottom, replication II in the middle, and replication III on top of the pile.

Observations in the cold storage were taken monthly for four months. Under common storage, monthly observations were taken for three months only because at the end of the third month all the bulbs in a particular treatment had either rotted or sprouted.

Data were collected on the weight and number of sound, sprouting and rotting bulbs. Rotting was not serious, hence, no datum was collected.

Index for rotting was based on the appearance of watery signs and tissue disintegration of the bulbs. The criterion for sprouting was the appearance of sprout measuring one-third of an inch in length. Bulbs which sprouted and rotted at the same time were classified as sprouting.

Shrinkage includes the loss in weight due to reduction in moisture content, bulb decay, and sprouting.

Methods of calculation

All data except for yield, number of bulbs per plot, and bulb diameter were expressed in percentages. The percentage data were transformed into angles by means of the arc sine transformation. The transformed data were treated by the orthogonal analysis of variance using the methods described by Cochran and Cox (1956) and Yates (1937). In the analysis, N′ represents the average or linear component of the response and N″, the curvature or quadratic component of the response to nitrogen. The two components were calculated as follows:

$$N' = N_2 + N_0$$
$$N'' = N_2 - 2N_1 + N_0$$

In other words, N′ is the response to the second increment of nitrogen, and N″ the difference between the response to the second and to the first increment.

RESULTS AND DISCUSSION

Field experiment

The effects of irrigation, nitrogen fertilization, maleic hydrazide and variety on:

Yields of bulbs. The yield of bulbs (including the rotten ones) was affected only by variety and nitrogen. Granex yielded 6.84 kilograms while Excel gave 5.15 kilograms per plot of seven square meters.

The application of fertilizer significantly increased the yields of the onions over the control. Maximum yield was obtained from the application of 60 kilograms of nitrogen per hectare; however, it did not differ significantly from plots fertilized with 120 kilograms (table 1).

TABLE 1.—*The main effect of nitrogen on the yield of onions*

NITROGEN	YIELD
kg./ha.	*kg./7 sq.m.*
0	5.36
60	6.61
120	6.03
Mean	6.00

Maleic hydrazide and irrigation treatments did not affect the yield and no interactions were significant.

Total number of bulbs per plot. Neither the main nor the interaction effects of the treatments had any influence on the total number of bulbs per plot.

Size of bulbs. The two varieties differed in bulb size: Granex had a diameter of 4.81 centimeters while Excel had 4.25 centimeters. Their difference of 0.56 centimeters, although highly significant, seemed small to be of practical importance.

The main effects of irrigation and nitrogen and their interaction were significant (table 2). The application of 60 and 120 kilograms of nitrogen per hectare increased the diameter of the bulbs over the control by 1.43 and 1.10 centimeters, respectively. The 120-kilogram rate tended to decrease bulb size. On the bases of these results, it would be safe to conclude that yield was directly influenced by bulb size since the number of bulbs per plot did not vary with the different treatments.

TABLE 2.—*The main and interaction effects of irrigation and nitrogen on the diameter of onion bulbs in centimeters*

FACTOR	KILOGRAMS OF NITROGEN PER HECTARE			MEAN
	0	60	120	
Irrigated	3.71	5.62	5.08	4.80
Non-irrigated	3.66	4.61	4.49	4.25
Mean	3.69	5.12	4.79	4.53

Irrigation also increased bulb size but the difference was too small to result in a significant increase in yield. The two first-order interactions of $N' \times I$ and $N'' \times I$ indicated that fertilizer increased bulb size more in irrigated than in the non-irrigated plots. Ware (1941) obtained a similar increase in yield of several vegetables including onion by applying irrigation water in combination with fertilizer and organic matter.

Maleic hydrazide treatment did not have any effect on the size of the onion bulbs.

Percentage of field rotten bulbs. The percentage of field rotting increased with increases in nitrogen fertilization (table 3). Unfertilized plants had the fewest rotten bulbs while those which received

120 kilograms of nitrogen per hectare had the most. Plants fertilized with 60 kilograms of nitrogen were intermediate.

TABLE 3.—*The main effect of nitrogen on the amount of rotten bulbs at harvest*

NITROGEN	ROTTEN BULBS
kg./ha.	*per cent*
0	5.98
60	10.19
120	14.60
Mean	10.26

The main effect of variety and its interaction with irrigation were both significant (table 4). Granex rotted more than Excel and in the irrigated plots, Granex rotted proportionately more than Excel. It seemed that irrigation kas an important factor although the experimental design could not very well give a definite conclusion. However, in a study of two varieties of onions, Drinkwater and Janes (1955) showed that a higher proportion of bulb decay was obtained from the heavy-and-frequent irrigation treatment.

TABLE 4.—*The main effect of variety and the interaction effect of variety × irrigation on the amount of rotten bulbs at harvest in per cent*

VARIETY	IRRIGATED	NON-IRRIGATED	MEAN
Excel	9.07	5.21	7.14
Granex	18.66	8.09	13.38
Mean	13.87	6.65	10.26

The main effect of irrigation and maleic hydrazide did not affect the percentage of rotting bulbs.

Bulb composition

Effects of irrigation, nitrogen fertilization, maleic hydrazide and variety on:

Total nitrogen content of bulbs. The two varieties significantly differed in total nitrogen content. Excel had 1.71 per cent while Granex had 1.55 per cent of nitrogen. Irrigation and nitrogen and

maleic hydrazide spray did not have material effect on the nitrogen content of the bulbs.

Per cent soluble solids of bulbs. The bulbs fertilized with 60 kilograms of nitrogen per hectare gave significantly lower per cent soluble solids than the unfertilized bulbs and those that received 120 kilograms of nitrogen which have essentially the same percentage (table 5). The difference between the two varieties was also highly significant. Excel had 5.54 per cent soluble solids while Granex had 4.53 per cent.

TABLE 5.—*The main effect of nitrogen on the per cent soluble solid content of bulbs of two varieties of onions*

NITROGEN	SOLUBLE SOLIDS
kg./ha.	
0	5.18
60	4.77
120	5.15
Mean	5.03

Irrigation and maleic hydrazide did not affect the soluble solids of the bulbs and no interactions were significant.

Per cent dry matter of bulbs. A highly significant difference in dry matter was observed between the two varieties. Granex had a higher percentage of dry matter, 7.03 per cent, as compared to Excel, which had 6.51 per cent. Irrigation, nitrogen and maleic hydrazide spray did not have any effect. According to Paterson and Wittwer (1953) no differences were found in percentages of dry matter and total nitrogen between MH-treated and untreated Y-40 onion bulbs examined before and after 18 months of storage.

Curing phase

Effects of irrigation, nitrogen fertilization, maleic hydrazide spray and variety on:

Per cent rotten bulbs during curing. Rotting differed highly significantly between the control and the fertilized plots (table 6). Rotting was inversely related to nitrogen application. Bulbs from plots fertilized with 60 and 120 kilograms of nitrogen per hectare rotted about half as much as bulbs from the unfertilized plots. Like-

wise, the varieties differed significantly—Granex had 7.63 per cent rotting while Excel had 5.20 per cent.

TABLE 6.—*The main effect of nitrogen on the percentage of rotten bulbs during curing*

NITROGEN	ROTTEN BULBS
kg./ha.	
0	8.33
60	7.34
120	3.57
Mean	6.41

Irrigation and maleic hydrazide had no apparent effect on the number of rotten bulbs during curing and none of the interactions were significant.

Shrinkage percentage during curing. The fertilizer treatments had a highly significant influence on shrinkage loss. Shrinkage was inversely related to nitrogen application. Bulbs under high nitrogen rotted less than the control and those that received a medium amount of nitrogen. The high shrinkage loss on unfertilized bulbs was largely the effect of the high percentage of rotting on the same bulbs (table 7).

TABLE 7.—*The main effect of nitrogen on the shrinkage loss of sound bulbs during curing*

NITROGEN	SHRINKAGE PERCENTAGE
kg./ha.	
0	6.89
60	5.53
120	4.36
Mean	5.59

The third-order interaction of $V \times MH \times N'' \times I$ was significant for shrinkage which was also reflected to the other interactions of $V \times I$, $MH \times N' \times I$ and $V \times N'' \times I$. This indicated that both unsprayed bulbs of Granex and Excel did not shrink as much as did all other treatments under high nitrogen level. The main effects of the other treatments were not significant. It is evi-

dent that four treatment combinations deviated from these previously mentioned effects (table 8 and fig. 1). Bulbs from sprayed plots of both varieties when irrigated and fertilized with 120 kilograms of nitrogen lost much more weight than those from the sprayed plots. The Granex plots irrigated and fertilized with 60 and 120 kilograms of nitrogen showed more shrinkage when not sprayed than when sprayed with maleic hydrazide. These deviations are responsible for the interaction, $V \times MH \times N'' \times I$. This shrinkage response was, probably, due to the location of the samples in the curing pile. The samples might have been in the bottom of the pile where circulation was comparatively poor. The slow drying of the bulbs most likely enhanced the growth of organisms that caused rotting which eventually influenced shrinkage.

TABLE 8.—*The interaction effect of variety × maleic hydrazide × nitrogen × irrigation on per cent shrinkage during curing*

FACTOR		KILOGRAMS OF NITROGEN PER HECTARE			MEAN
		0	60	120	
Irrigated:					
No MH	Excel	7.09	5.31	6.20	6.20
	Granex	6.53	7.36	6.13	6.67
With MH	Excel	7.47	5.07	3.84	5.46
	Granex	7.78	5.83	3.81	5.81
No irrigation:					
No MH	Excel	6.71	6.34	3.76	5.60
	Granex	7.32	4.14	3.76	5.07
With MH	Excel	6.91	5.31	3.78	5.33
	Granex	5.25	4.88	3.53	4.55
	Mean	6.89	5.53	4.36	5.59

Storage and time comparison

Effects of irrigation, nitrogen fertilization, maleic rydrazide spray and variety on bulbs under common storage

Per cent sound bulbs. The monthly behavior of the sound bulbs and the effect of the different treatments on sound bulbs stored under common storage are summarized in tables 9 and 10, respectively. The proportion of sound bulbs was not affected by either irrigation, nitrogen, maleic hydrazide or variety, used singly. The percentage of sound bulbs, regardless of the treatments, was greatly

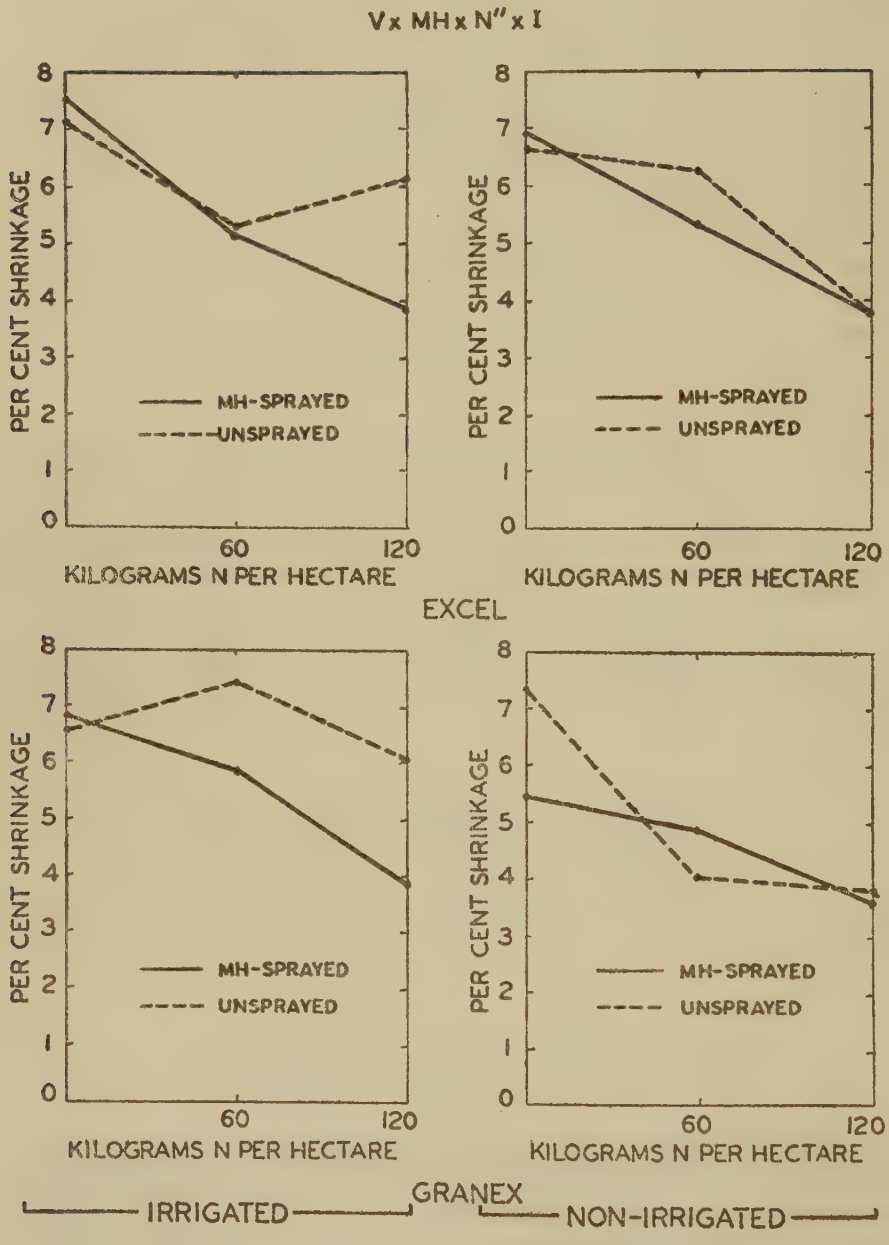

Fig. 1.—Shrinkage percentage of sound bulbs during curing.

[illegible] The [illegible] amount of only 1.12 per cent of wood value was left at the end of the twenty years. The V / MH / S" [illegible] The [illegible] was applicable for wood value, however, as practical significance was reduced because the percentage of wood value left was very small so that it would not be profitable either way.

Table 1.—Summary data of the monthly [illegible] per cent wood, [illegible] and money value and average percentage of wood value saved when [illegible]

[illegible]	[illegible]		
	1	4	6
	per cent		
Wood value	5.10	2.10	1.12
Operating value	1	2.1	4.2
Money value	2.10	1.1	2.1
Average	2.1	2.1	2.10

TABLE 10.—Summary data of the effect of the [illegible] on the percentage of wood, operating and selling value and average percentage of wood value saved when [illegible] for [illegible]

[illegible]	1	2	4	6	[illegible]
Wood value:					
1st month	10	10	10	10	
2nd "	10	10	10	10	V / MH / S"
3rd "	10	10	10	10	
Operating value:					
1st month	40	40	40	40	
2nd "	10	10	10	10	MH / S" / 1;
3rd "	10	*	*	**	V / MH / S"
Selling value					
1st month	10	10	10	10	
2nd "	10	10	10	10	
3rd "	10	10	10	**	
Average:					
1st month	10	*	10	10	
2nd "	10	10	10	10	
3rd "	10	10	10	10	

* [illegible] as an example.

Per cent sprouted bulbs. The monthly sprouting behavior and the effects of the different treatments on sprouting are summarized in tables 9 and 10, respectively. Irrigation did not have any effect. Nitrogen, maleic hydrazide and variety significantly influenced sprout growth toward the end of the storage period. Granex had 6.50 per cent sprouting while Excel had 1.90 per cent. The MH-sprayed bulbs had 3.33 per cent sprouting as compared to 5.06 per cent for the unsprayed ones.

Bulbs fertilized with either 60 or 120 kilograms of nitrogen per hectare sprouted twice as much as those which were not fertilized (table 11).

TABLE 11.—*The main effect of nitrogen on the percentage of sprouted bulbs*

NITROGEN	SPROUTING
kg./ha.	*per cent*
0	2.58
60	5.22
120	4.79
Mean	4.18

While some of the interactions were significant, the total sprouting was so small that these had no practical significance. The large number of zero values made these interactions subject to doubt. Also, the percentage of sound bulbs was not affected; therefore, sprouting was not important.

Per cent rotten bulbs. Only variety affected the number of rotten bulbs at the end of the storage period. Excel had 90.90 per cent rotting while Granex had 85.30 per cent or an average of about 88 per cent (table 9). The rest of the treatments did not affect the number of rotten bulbs and no interactions were significant (table 10).

Per cent shrinkage loss of sound bulbs. Shrinkage was not important at the end of the storage period. There were no marked differences in per cent weight loss due to shrinkage among the different treatments. The bulbs in all the treatments equally and continuously lost an average weight of 26.06 per cent (tables 9 and 10).

Effects of irrigation, nitrogen fertilization, maleic hydrazide spray and variety on bulbs stored under cold storage

Per cent sound bulbs. A summary of the monthly percentage of sound bulbs is shown in table 12. The proportion of sound bulbs was largely influenced by the main effects of variety and maleic hydrazide beginning the second month of storage (table 13). Maleic

TABLE 12.—*Summary table of the monthly percentage of sound, sprouting and rotting bulbs and per cent shrinkage on bulbs stored under cold storage for four months*

OBSERVATION	MONTH			
	1	2	3	4
Sound bulbs	96.86	91.23	70.85	40.09
Sprouting bulbs	Trace [a]	5.05	23.65	53.85
Rotting bulbs	2.77	3.76	5.36	6.16
Shrinkage loss	1.89	3.20	5.22	9.81

[a] Trace = Less than 1 per cent.

TABLE 13.—*Summary table of the effects of various treatments on percentages of sound, sprouting and rotting bulbs and shrinkage of onions stored for four months in cold storage*

OBSERVATION	I	N	MH	V	INTERACTION
Sound bulbs:					
1st month	ns	ns	ns	ns	MH × N″
2nd "	ns	ns	*	**	V × MH; V × N′
3rd "	ns	ns	*	**	
4th "	ns	ns	**	**	MH × N″; V × N′
Sprouting bulbs:					
1st month	ns	ns	ns	ns	
2nd "	ns	ns	**	**	V × I; V × MH
3rd "	ns	ns	**	**	MH × N″; MH × I; V × N′
4th "	ns	ns	**	**	V × N′; V × MH
Rotting bulbs:					
1st month	ns	ns	ns	ns	
2nd "	ns	ns	ns	ns	
3rd "	ns	ns	*	ns	MH × N″; MH × N″ × I
4th "	ns	ns	*	ns	
Shrinkage loss:					
1st month	*	ns	ns	ns	
2nd "	ns	ns	ns	ns	MH × N″
3rd "	ns	ns	ns	ns	
4th "	ns	ns	*	ns	

hydrazide-sprayed bulbs significantly gave a greater number of sound bulbs than the unsprayed ones and Granex had more sound bulbs than Excel throughout the storage period. Thus, at the end of the storage period, the unsprayed plots had an average of only 23.38 per cent sound bulbs, while onions sprayed with MH had 55.80 per cent. Likewise, Granex had an average total of 45.19 per cent sound bulbs while Excel had 33.98 per cent. This was largely the result of the effects of these treatments on sprouting, viz., Granex, which had less sprouting, had a greater number of sound bulbs than Excel, and the efficiency of maleic hydrazide in minimizing sprout growth resulted in greater percentage of sound bulbs.

The *V* × *MH* interaction for sound bulbs during the second growth was significant. Excel had fewer sound bulbs than Granex when not sprayed but they did not differ when sprayed with maleic hydrazide (table 14). This was attributed to the greater percentage of sprouted Excel bulbs on the no-MH treatment. The other interactions also were significant but the differences in sound bulbs were small as to render these with no practical significance. Irrigation did not have any effect.

TABLE 14.—*The interaction effect of maleic hydrazide* × *variety on the percentage of sound bulbs*

VARIETY	MALEIC HYDRAZIDE		MEAN
	0 ppm	2500 ppm	
Excel	83.50	91.82	87.66
Granex	94.47	95.11	94.79
Mean	88.99	93.47	91.23

There was an inverse relation between the nitrogen and soluble solid contents of the bulbs and the percentage of sound bulbs. Granex, which had a lower nitrogen and soluble solid contents, had a greater percentage of sound bulbs remaining at the end of the storage period than Excel, which was high in these constituents. On the other hand, the dry matter content of the bulbs was directly related to the number of sound bulbs. Granex, which had a high percentage of dry matter, had a greater percentage of sound bulbs than Excel. This result corroborates the findings of Foskett and Peterson (1950) that onions with high dry matter had less sprouting and higher sound bulbs than onions with low dry matter during stor-

age. However, the result obtained from this experiment cannot be used to confirm absolutely the result gathered by Foskett and Peterson because only two varieties were used. Whereas, these two workers used 60 varieties and hybrids of onions.

Per cent sprouting bulbs. It is evident from the data on table 12 that sprouting accounted for most of the losses during storage (53.85 per cent). The main effect of maleic hydrazide and variety and their interaction were largely responsible in influencing sprouting (table 13). Granex significantly gave less sprouting than Excel beginning the second month of storage. At the end of the storage period, Granex had an average sprouting of 46.89 per cent as compared to 60.80 per cent for Excel.

The application of maleic hydrazide minimized sprout growth to as low as 35.57 per cent, or about half that of the unsprayed bulbs which was 73.13 per cent. This result confirmed those of other workers, viz., pre-harvest sprays of MH inhibit sprouting in storage. However, the effectiveness of MH in reducing sprout growth in this experiment was not very satisfactory. The percentage of sprouting was somewhat higher than what others have reported. It is possible that many of the onions were already mature when the spray was applied two weeks before the plants were harvested.

The variety × maleic hydrazide interaction markedly affected sprouting of the two varieties of onions during the second and fourth months of storage. In the second month, maleic hydrazide reduced sprouting on Excel but had little effect on Granex (table 15).

TABLE 15.—*The interaction effect of maleic hydrazide × variety on the percentage of sprouted bulbs*

MALEIC HYDRAZIDE	VARIETY		MEAN
	Excel	Granex	
0 ppm	13.32	2.13	7.73
2500 ppm	4.30	0.43	2.37
Mean	8.81	1.28	5.05

However, in the fourth month, MH reduced sprouting on Granex more than on Excel (table 16). In other words, Granex had much less sprouting than Excel when sprayed while there was little difference when not sprayed. This behavior could have been due to

TABLE 16.—*The interaction effect of variety × maleic hydrazide on the percentage of sprouted bulbs*

MALEIC HYDRAZIDE	VARIETY		MEAN
	Excel	Granex	
0 ppm	76.42	67.84	72.13
2500 ppm	45.19	25.95	35.57
Mean	60.81	46.90	53.85

the fact that Excel sprouted earlier than Granex in storage. It is supposed that in the second month there was not enough sprouting on the unsprayed Granex bulbs to show the effect of MH on the sprayed bulbs. The other interactions were also significant for sprouting but there was no practical significance indicated because the differences in sprouting were small.

The main effects of nitrogen and irrigation did not affect the percentage of sprouted bulbs.

Per cent rotten bulbs. The percentage of rotten bulbs and the effect of the different factors on these bulbs are summarized in tables 12 and 13. Maleic hydrazide affected the percentage of rotten bulbs beginning the third month of storage. Application of the chemical increased rotting to 7.71 per cent at the end of the storage period, or about twice that of unsprayed bulbs which was 4.60 per cent. However, sprayed bulbs still gave a higher proportion of sound bulbs because the "reduce-sprouting" effect of the chemical more than offset its "increase-rotting" effect.

Paterson and Wittwer (1953) and Acosta and York (1957) obtained a similar increase in rotting from onions treated with maleic hydrazide. The latter authors stated that pathogen present on or in the bulbs appeared to become established better in bulbs whose physiology has been altered by maleic hydrazide. Greulach and Atchison, as cited by Isenberg (1956), have shown that the physiological development of onion bulbs was altered by maleic hydrazide. They found that mitosis and cell division were inhibited while enlargement was not affected when onions were grown in nutrient solution with 1 part per million of maleic hydrazide.

The significant interactions of $MH \times N''$ and $MH \times N'' \times I$ in the third month were variations of the difference due to maleic

hydrazide; also, the differences were small and of no practical significance.

The other treatments did not have any effect on the percentage of rotten bulbs.

Per cent shrinkage loss on sound bulbs. The monthly losses due to shrinkage are shown in table 12, while the effect of the different treatments on shrinkage is shown in table 13. Shrinkage was not affected by the different treatments except by irrigation during the first month and maleic hydrazide during the fourth month of storage. Irrigated plants had 2.33 per cent shrinkage loss while the non-irrigated plants had 1.45 per cent. Also, onions sprayed with maleic hydrazide lost more weight (11.80 per cent) than the unsprayed bulbs (7.82 per cent). This difference in shrinkage cannot be said to be largely or partly due to the fact that the sprayed bulbs had more rotting than the unsprayed bulbs because the difference in rotting was small. Sprouting, which accounted for most of the losses in storage, was inversely related to shrinkage. Probably, sprouting did not greatly reduce the weight of the bulbs. The $MH \times N''$ interaction for shrinkage was significant but of no importance.

Other observations

Effects of storage location and months on the percentage of sound, sprouting and rotting bulbs

In order to see whether or not storage location would show possible effects on the number of sound, sprouted, and rotten bulbs the replication data for the several months of storage were analyzed by the ordinary analysis of variance. This information is important largely in suggesting future development in storage technique to obtain the maximum useful information from a storage experiment.

Under common storage

Sound bulbs. In considering the entire common storage experiment it was noted that the percentage of sound bulbs was significantly greater in replication I (40.20 per cent), which was at the bottom of the pile, than in replication III (20.46 per cent), which was on top of the storage pile (table 17). Replication II was intermediate. This difference owing to storage location was due to the greater percentage of rotting in replication III.

TABLE 17.—*Summary table of the effect of storage location on the percentage sprouted and rotten bulbs after three months of common storage*

REPLICATION	SOUND BULBS		SPROUTED BULBS		ROTTEN BULBS	
	Total	Mean	Total	Mean	Total	Mean
I	120.74	40.20	7.33	2.44	171.92	57.30
II	92.87	30.93	4.45	1.48	203.55	67.85
III	61.46	20.46	7.12	2.32	231.60	77.12
H.S.D. 5%		12.22		—		11.04
1%		—		—		—

The percentage of sound bulbs decreased significantly from month to month. Loss was greatest during the first and second months (table 18).

TABLE 18.—*Summary table of the effect of length of storage period on percentage of sound, sprouted and rotten bulbs*

MONTH	SOUND BULBS		SPROUTED BULBS		ROTTEN BULBS	
	Total	Mean	Total	Mean	Total	Mean
1st	182.87	60.90	0	0	117.13	39.00
2nd	69.04	23.00	6.29	2.09	225.64	75.14
3rd	23.16	7.71	12.61	4.12	264.30	88.10
H.S.D. 5%		12.22		1.65		11.04
1%		20.25		2.73		18.30

Sprouting bulbs. There were no significant differences among the different replications (table 17). This was due to the fact that more of the bulbs had already rotted and, therefore, the number that could sprout was much reduced.

Sprouting occurred late in the storage period. The difference between months were highly significant; however, the results are rather doubtful because the remaining number of sound bulbs that could sprout was small (table 18).

Rotting bulbs. Storage location had a highly significant effect on rotting (table 17). Less rotting was noted in replication I with a mean of 57.30 per cent than in replication III with a mean of 77.12 per cent. Replication II was intermediate. The high temperature caused by the galvanized roofing of the Shed House during day time must have accounted for the observed differences in rotting.

The percentage of rotting was directly proportional to the length of storage period. Monthly rotting was great, especially during the first and second months (table 18).

Under cold storage

Sound bulbs. The location of the bulbs in storage had a significant effect on sound bulbs (table 19). More sound bulbs were noted in replication I than in the other replications. Replications II and III did not differ significantly. These differences in percentage of sound bulb were due to the greater percentage of sprouting and rotting in replications II and III.

TABLE 19.—*Summary table of the effect of location on the percentage of sound, sprouted and rotten bulbs after four months of cold storage*

REPLICATION	SOUND BULBS		SPROUTED BULBS		ROTTEN BULBS	
	Total	Mean	Total	Mean	Total	Mean
I	317.30	79.33	74.33	18.58	8.65	2.16
II	286.09	71.52	97.90	24.47	13.39	4.10
III	293.67	73.42	76.53	19.13	28.69	7.17
H.S.D. 5%		5.81		—		2.87
1%		—		—		4.35

Time had a highly significant effect on the number of sound bulbs. During the first and second months, there was a very slight decrease on the percentage of sound bulbs. Loss was greatest during the third and fourth months (table 20).

TABLE 20.—*Summary table of the effect of length of storage period on the number of sound, sprouted and rotten bulbs after four months of cold storage*

MONTH	SOUND BULBS		SPROUTED BULBS		ROTTEN BULBS	
	Total	Mean	Total	Mean	Total	Mean
1st	290.60	96.77	1.15	0.38	8.32	2.77
2nd	273.68	91.14	15.11	5.03	11.32	3.77
3rd	212.54	70.78	70.91	23.61	16.07	5.35
4th	120.24	40.04	161.59	53.81	18.02	6.00
H.S.D. 5%		7.42		6.95		—
1%		10.82		10.13		—

Sprouting bulbs. Table 19 shows that storage location did not have any apparent effect on the percentage of sprouting bulbs.

The month had a significant effect on sprouting. During the first and second months, sprouting was only slight. Sprout growth abruptly increased during the third and fourth months. These data show that there was an increase in sprouting proportional to the length of storage (table 20).

It was noted that in the third month, replication II sprouted more than the other replications; however, the differences were not significant due to low precision. This response was probably due to temperature. Poor ventilation in the middle of the pile, probably, resulted in a higher temperature, thus inducing a slightly more sprouting there than at the top and bottom of the pile.

Rotting bulbs. Replication III had the greatest percentage of rotten bulbs while replication I had the least (table 19). Replication II was intermediate. The high rotting percentage on replication III, which was on top of the pile, was largely induced by the water that dripped on the bulbs from the ceiling of the cold storage room. This response might have been partly due also to temperature gradients and variations in relative humidity and composition of the atmosphere from the top to the bottom of the pile. It is believed that the temperature and relative humidity were higher at the upper portion of the pile, thus favoring the growth of rot organisms. On the other hand, the temperature was lower at the bottom of the pile as it was protected from the dripping water, and conditions were less favorable for the growth of the rot organisms.

It is evident from the data on table 20 that month did not have any apparent effect on the percentage of rotting during storage.

Considering all these differences in replications, it seems that it is important to take into account the proper arrangement of replications in storage if reliable information is to be attained on the true differences among treatments.

Morphological effect of maleic hydrazide

Five each of sprayed and unsprayed bulbs were examined at the end of the storage period on the fourth month. The bulbs which received pre-harvest application of maleic hydrazide were puffy. Wittwer and Paterson (1951) reported that early spraying with maleic hydrazide resulted in puffy bulbs.

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THE PERFORMANCE OF A CROSS-SECTION SAMPLE OF STANDARD U. S. DOUBLE CROSSES DURING ONE DRY SEASON IN LAGUNA, PHILIPPINES[1]

I. S. Santos and I. C. Cagampang

Twenty-four double-cross hybrids from different latitudes in the United States of America as represented by Wisconsin (43.8°N), Iowa, Missouri, Tennessee, North Carolina, and Georgia (31.5°N) were tested at College, Los Baños, Laguna (14°10'N), Philippines during the 1953-54 dry season. In general, double crosses from the last three states mentioned performed better than the rest of the U.S. hybrids. Nine U.S. hybrids gave grain yields that were higher than that of the best local variety, College Yellow Flint. Among these, U.S. hybrid Tennessee 0131 significantly outyielded the latter.

United States corn hybrids are widely known to be at least partly responsible for the increased yields of corn in the United States of America. Many Filipino farmers and agriculturists have thus been led to ask whether American double crosses could be used in the Philippines to improve the yield of corn.

U. S. hybrids have been bred for high grain yields and are recommended for planting in areas near the site of performance tests. These hybrids generally do better in areas in which they are recommended for planting than elsewhere. Testing such hybrids in areas other than those for which they are recommended would seem to have only two objectives: (1) to obtain basic information on the behavior or performance of hybrids when planted in areas other than those for which they were bred, e.g., when grown at different latitudes and (2) to determine if these hybrids can be of any value to the agriculture in such other areas, i.e., if they outyield the corn presently cultivated in those areas. The study reported in this paper was conducted at the Central Experiment Station, University of the Philippines College of Agriculture during the 1953-54 dry season with these two objectives in view.

MATERIALS AND METHODS

Twenty-four open-pedigreed double-cross hybrids obtained from the different agricultural experiment stations in the United

[1] Central Experiment Station Contribution No. 2074.

States were used in this study: Wisconsin 685, Wisconsin 641AA, Wisconsin 575, and Wisconsin 464A from Madison, Wisconsin; Iowa 4412, Iowa 4622, and Iowa 4697 from Ames, Iowa; Missouri 804, Missouri 8, and Missouri 843, from Columbia, Missouri; Tennessee 0142, Tennessee 0107, and Tennessee 0114 from Knoxville, Tennessee; North Carolina 31, North Carolina 29, and North Carolina 27, from Raleigh, North Carolina; and GCP 1214, GCP 3129, and GCP 3222, from Coastal Plains Experiment Station, Georgia. US 523W, Dixie 18, and Dixie 80 are Federal Experiment Station hybrids. The hybrids from Wisconsin, Iowa, Missouri, and Georgia, Dixie 18, Dixie 80, and North Carolina 27 are yellow dents; others from Tennessee, North Carolina 29, North Carolina 31, and US 523W are white dents.

The pedigrees of these U.S. hybrids are as follows:

Wisconsin	685	(Wf9 × 22) (40B × M14)
	575	(W64A × W32) (M14 × W182D)
	641AA	(Wf9 × M14) (32 × 187)
	464A	(M13-R × R3) (153-R × 374)
Iowa	4459	(Wf9 × Hy) (Os420 × 187-2)
	4397	(Wf9 × 1205) (M14 × W22)
	4412	(Wf9 × Hy) (187-2 × M14)
	4622	(Wf9 × 38-11) (B14 × W182D)
Missouri	804	(38-11 × CI.21E) (C1.7 × K4)
	8	(K4 × B2) (L3 × G)
	843	(Wf9 × Oh7A) (B10 × C103)
Tennessee	0131	(T121 × T119) (T111 × T115)
	0107	(T101 × T105) (T113 × T111)
	0142	(T113 × T115) (T111 × T101)
	0114	(T115 × T111) (T105 × T101)
North Carolina	31	(Tex 61M × K64) (NC33 × NC34)
	29	(L10 × Tex 61M) (NC33 × NC34)
	27	(KYS × C121) (NC7 × NC13)
Georgia	1214	(8950 × GT106) (GT112 × L578)
	3129	(Mp315 × Mp317) (GT3 × Mp311)
	3222	(F44 × GT166) (GT112 × L578)
Dixie 18		(F6 × F44) (L578 × GT112)
82		(NC7 × T204) (CI.21 × GT112)
US523W		(K55 × K64) (Ky49 × Ky27)

Wf9 is a widely used inbred line in the U.S. cornbelt. It is present in the pedigrees of three of the four hybrids from Wisconsin, of all four hybrids from Iowa, and one of the three hybrids from Missouri. F44 is in the pedigree of one standard Philippine double cross.

The Tennessee and Georgia hybrids were experimental and of these, only Tennessee 0114 is currently being produced commercially.[2] When this hybrid was released, it was given the designation Dixie 29. Dixie is a widely grown hybrid in southern U.S.A.

Three local entries were used as checks, namely: College Yellow Flint, Cuban Yellow Flint, and one experimental double-cross hybrid produced by the Division of Plant Breeding, (A105 × A106) (A112 × A113). A105 and A106 are lines derived from College Yellow Flint; A112 and A113, from Cuban Yellow Flint. College Yellow Flint is a high-yielding open-pollinated variety of local origin. Cuban Yellow Flint is an introduced open-pollinated variety that has been found adapted to local growing conditions.

The randomized complete-block design with two replications was used in this study. Each plot was 3 rows wide and 17 hills long. The rows were 1 meter apart; the distance between successive hills in the row, 50 centimeters.

On November 12, 1953, the U.S. hybrids and the checks were planted. Four to eight kernels, depending on the percentage germination of each hybrid, were dropped to a hill. Border rows of local corn were planted on each side of the block. Two weeks after planting, each hill was thinned to a maximum of two plants.

Ammonium phosphate fertilizer was applied at the rate of 150 kg. to a hectare at the time of planting. Ammonium sulfate was applied four weeks after planting at the rate of 125 kg. to a hectare.

Two weeks after planting, an animal-drawn cultivator was used to control the weeds. The plants were hilled up about four weeks after planting. After hilling-up, subsequent weed control was effected by means of the garden hoe.

Date of silking for each plot was recorded when about half of the plants in the plot had ears showing silks. Days to silking was computed as the number of days from date of planting to date of silking.

Height of plants was measured as the distance from the ground level to the tip of the tassel. For each plot, heights of two plants chosen at random from the central row were measured. The mean

[2] Personal communication of the senior author with George F. Sprague, Leader, Corn and Sorghum Investigations, Crops Research Division, Agricultural Research Service, United States Department of Agriculture, Beltsville, Md. dated January 16, 1961.

of these two height readings was considered the mean height of the plants in the plot.

Only two-plant hills on the central row of each plot surrounded by either one-plant or two-plant hills on all four sides were harvested. Hills that were not included in the yield determination were chopped down a week before harvest. These included the two end hills. The hills that remained were counted and their number, recorded for each plot.

The ears harvested from each plot were classified into good and poor ears. Poorly filled ears were classified as poor; short but well-filled ears were considered good. The numbers of good and poor ears were recorded. The number of good ears per plant was obtained by dividing the number of good ears by the total number of plants.

Five representative ears were chosen from each plot and their lengths were measured. The mean of these five length readings was considered the mean length of the ears from the plot.

The ears were dried in a forced-hot-air dryer to facilitate shelling. The ears were not shelled and a shelling percentage of 80 was assumed. Ears from each plot were weighed separately. Grain samples for each plot were taken from five ears taken at random. The moisture content of the grains was determined with the use of the Universal Electronic Moisture Tester. Plot yields in pounds of ears corresponding to a certain number of hills harvested were converted to hectare yields in cavans at 16 per cent moisture using the following formula:

$$Y = P \times \frac{10{,}000}{N \times 0.5} \times \frac{1}{58.5 \times 2.2} \times \frac{100 - \text{M.C.}}{84} \times 0.80$$

Where,

Y = yield in cavans of shelled corn per hectare at 16 per cent moisture
P = plot yield in pounds of ear corn corresponding to a certain number (N) of hills harvested
10,000 = No. of sq. m. per hectare
N = No. of hills harvested
0.5 = No. of sq. m. occupied by a hill
58.5 = No. of kg. per cavan
2.2 = No. of pounds per kilogram
M.C. = moisture content of shelled grains in per cent
1/84 = factor for converting into weight at 16 per cent moisture
0.80 = assumed shelling percentage

The stalks, leaves, and husks were allowed to dry in the field for some time before they were harvested. These were weighed immediately after harvest and three-stalk samples selected at random from each plot were weighed and placed in the forced-hot-air dryer. The samples were allowed to dry to "constant weight" and then weighed again. Per cent dry matter of the sample (hence, of the stover harvested from the plot) was computed by dividing the weight of stover after drying by its weight before drying.

Stover yield in tons per hectare at 16 per cent moisture was computed using the following formula:

$$Y = P \times \frac{10{,}000}{N \times 0.5} \times \frac{1}{1000 \times 2.2} \times \frac{D}{84}$$

where,

Y = stover yield in tons per hectare at 16 per cent moisture
P = plot yield in pounds of stover corresponding to a certain number (N) of hills harvested
1000 = No. of kg. per ton
2.2 = No. of pounds per kilogram
D = per cent dry matter as determined from the stover sample dried to constant weight

The other figures have already been explained in connection with the computation of hectare grain yields.

Fodder includes the stalks, leaves, husks, cobs, and grains. For the purpose of computing fodder yields, plot yields in pounds of ear corn were converted to hectare yields in kilograms of ear corn using the following formula:

$$Y = P \times \frac{10{,}000}{N \times 0.5} \times \frac{1}{2.2} \times \frac{100 - \text{M.C.}}{84}$$

where,

Y = yield of ear corn in kilograms per hectare
P = plot yield in pounds of ear corn corresponding to a certain number (N) of hills harvested, and

the rest of the symbols and figures are as explained in either or both the two formulas previously given.

Stover yield in kilograms per hectare (tons per ha. x 1000) and ear corn yield in kilograms per hectare were summed to give *fodder yield* in kilograms per hectare which was then divided by 1,000 to convert it to tons per hectare.

RESULTS

Weather data for the season of test are presented in table 1. Total rainfall for the four months was 214.0 mm. which is about the

TABLE 1.—*Total monthly rainfall and monthly mean temperature and relative humidity for November and December, 1953 and January and February, 1954 at College, Los Baños, Laguna, Philippines* [a]

MONTH	RAINFALL		TEMPERATURE		RELATIVE HUMIDITY
	in.	mm.	°F	°C	per cent
November, 1953	5.43	137.9	80.4	26.9	—[b]
December, 1953	1.80	45.9	77.9	25.5	—[b]
January, 1954	1.13	28.7	78.3	25.7	86
February, 1954	0.06	1.5	79.2	26.2	85
Total or mean	8.42	214.0	79.0	26.1	85.5

[a] 68 ft. above sea level
[b] No observations made

minimum rainfall necessary for a satisfactory crop. The distribution, however, was all right with enough rainfall during flowering time in December. As is true in other parts of the northern hemisphere, the temperatures from November to February were lower than in the other months. However, these temperatures are not very different from the long-time annual mean 26.9°C (80.4°F) for College, Laguna, Philippines.

Stover yields and grain yields are given, by replication, in table 2. The entries are arranged in descending order based on grain yield. Rank based on stover yield is indicated in the last column. This was done to give the reader an idea as to how the entries ranked in terms of grain and of stover yields. The high grain-yielders, Tennessee 0131 and Tennessee 0107 placed 12th and 8th, respectively, in stover yield. The high stover-yielders, North Carolina 27 and North Carolina 29, placed 13th and 14th, respectively, in grain yield. Except for Iowa 4412, Iowa 4622, Wisconsin 575, Wisconsin 641AA, Wisconsin 464A, and Iowa 4337, which were both low grain-yielders and low stover-yielders, the high grain-yielders were medium stover-yielders and the high stover-yielders were medium grain-yielders.

Some U.S. hybrids were numerically better grain-yielders than College Yellow Flint and some were better stover-yielders than Cuban Yellow Flint, an acclimatized variety. Only Tennessee 0131, how-

TABLE 2.—*Grain yield (cavans per hectare)*[a] *and stover yield (tons per hectare) of 24 U.S. double crosses and three local entries, arranged in descending order based on grain yield. Central Experiment Station, University of the Philippines College of Agriculture, Laguna, Philippines, 1953-54 Dry Season*

ENTRY	GRAIN YIELD			STOVER YIELD			
	Replications		Mean	Replications		Mean	Rank
	I	II		I	II		
Tennessee 0131	80.0	94.4	87.2	3.15	3.97	3.56	12
Tennessee 0107	73.3	76.6	75.0	4.33	3.75	4.04	8
US 523W	78.4	68.2	73.3	3.16	2.09	2.63	15
Tennessee 0142	67.3	69.5	68.4	3.49	3.75	3.62	11
North Carolina 31	69.7	66.5	68.1	3.79	3.90	3.85	10
Dixie 82	58.6	75.5	67.1	4.06	3.90	3.98	9
GCP 1214	65.4	68.0	66.7	4.25	4.48	4.37	6
Tennessee 0114	51.6	77.3	64.5	2.60	3.46	3.03	14
GCP 3129	58.0	70.5	64.3	5.05	4.18	4.62	3
College Yellow Flint	59.0	64.2	61.6	2.38	2.60	2.49	18
(A105 × A106) (A112 × A113)	55.5	67.0	61.3	2.32	3.87	3.10	13
GCP 3222	58.3	64.1	61.2	3.53	4.61	4.07	7
North Carolina 29	66.7	54.3	60.6	6.18	3.61	4.90	2
North Carolina 27	49.6	71.4	60.5	4.92	5.14	5.03	1
Iowa 4459	61.3	58.4	59.9	1.87	1.62	1.75	21
Missouri 804	59.6	55.2	57.4	2.63	2.44	2.54	16.5
Dixie 18	54.3	58.4	56.4	4.72	4.23	4.48	4
Missouri 8	52.3	57.6	55.0	1.80	1.80	1.80	20
Iowa 4397	47.9	61.1	54.5	1.80	1.08	1.44	23
Missouri 843	56.4	47.2	51.8	2.81	2.26	2.54	16.5
Cuban Yellow Flint	54.8	46.5	50.7	4.47	4.40	4.44	5
Iowa 4412	33.0	66.8	49.9	2.24	1.80	2.02	19
Iowa 4622	41.3	50.2	45.8	1.70	1.50	1.60	22
Wisconsin 685	43.9	41.0	42.5	1.44	1.00	1.22	24
Wisconsin 575	45.0	39.4	42.2	0.83	0.85	0.84	27
Wisconsin 641AA	41.6	34.0	37.8	1.17	0.89	1.03	26
Wisconsin 464A	26.7	32.8	29.8	1.17	0.90	1.04	25
L.S.D. 0.05			16.7			1.11	
0.01			22.6			1.50	
H.S.D. 0.05			31.9			2.12	
0.01			37.6			2.49	

[a] 1 cavan of corn grain is equivalent to 58.5 kg.

ever, significantly outyielded College Yellow Flint. It should be mentioned at this point that the grain and stover yields of Tennessee 0131 in replication II are based on only three perfect-stand hills. It seemed highly probable that with more replications than

two, the second- and third-ranked hybrids might have been significantly better grain-producers than College Yellow Flint.

The only Philippine experimental hybrid in the test turned out to be only as good as College Yellow Flint in grain yield and a significantly poorer stover-yielder than Cuban Yellow Flint.

Table 3 summarizes means for grain, stover, and fodder yields together with those for plant height, days to silking, number of good

TABLE 3.—*Summary of agronomic characters of 24 U.S. double crosses and three local entries. Central Experiment Station, University of the Philippines College of Agriculture, Laguna, Philippines. 1953-54 Dry Season*

VARIETY AND LATITUDES [a]	PLANT HEIGHT	DAYS TO SILKING	GOOD EARS PER PLANT	EAR LENGTH	YIELD PER HECTARE		
					Grain	Stover	Fodder
	cm.	*number*	*number*	*cm.*	*cav.*	*tons*	*tons*
Wisconsin (42°N)							
Wisconsin 685	197	49	0.71	13.8	42.5	1.22	4.33
Wisconsin 575	181	47	0.58	11.5	42.2	0.84	3.93
Wisconsin 641AA	208	51	0.59	11.8	37.8	1.03	3.79
Wisconsin 464A	169	48	0.50	12.0	29.8	1.04	3.21
Mean	189	49	0.60	12.3	38.1	1.03	3.82
Iowa (41°N)							
Iowa 4459	234	52	0.76	15.3	59.9	1.75	6.13
Iowa 4397	205	51	0.76	13.5	54.6	1.44	5.43
Iowa 4412	222	54	0.62	13.3	49.9	2.02	5.67
Iowa 4622	209	53	0.68	13.8	45.8	1.60	4.95
Mean	218	53	0.71	14.0	52.6	1.70	5.55
Missouri (38°N)							
Missouri 804	255	56	0.69	17.5	57.4	2.54	6.73
Missouri 8	254	56	0.80	15.0	55.0	1.80	5.82
Missouri 843	204	56	0.68	14.5	51.9	2.54	6.32
Mean	238	56	0.72	15.7	54.8	2.29	6.29
Tennessee (36°N)							
T 0131	225	59	0.96	15.3	87.2	3.56	9.94
T 0107	259	57	0.82	14.8	75.0	4.04	9.52
T 0142	254	55	0.81	14.3	68.4	3.62	8.62
T 0114	226	57	0.82	13.5	64.5	3.03	7.74
Mean	241	57	0.85	14.5	73.8	3.56	8.96
North Carolina (35°N)							
NC 31	288	56	0.89	14.8	68.1	3.85	8.82
NC 29	288	58	0.73	14.5	60.6	4.90	9.32
NC 27	248	58	0.75	14.8	60.5	5.03	9.45
Mean	275	57	0.79	14.7	63.1	4.59	9.20

TABLE 3 (continued)

VARIETY AND LATITUDES [a]	PLANT HEIGHT	DAYS TO SILKING	GOOD EARS PER PLANT	EAR LENGTH	YIELD PER HECTARE		
					Grain	Stover	Fodder
Georgia (32°N)							
GCP 1214	263	59	0.88	15.3	66.7	4.37	9.25
GCP 3129	262	58	0.77	17.3	64.3	4.62	9.31
GCP 3222	310	58	0.92	14.0	61.2	4.07	8.55
Mean	278	58	0.86	15.5	64.1	4.35	9.04
Miscellaneous							
US 523W	249	54	0.90	15.3	73.3	2.63	7.98
Dixie 82	249	59	0.89	15.3	67.1	3.98	8.88
Dixie 18	275	60	0.79	14.3	56.4	4.48	8.60
Mean	258	58	0.86	15.0	65.6	3.70	8.49
Laguna, Philippines (14°10'N)							
College Yellow Flint	228	52	0.89	14.8	61.6	2.49	6.99
Local Hybrid [b]	247	55	0.95	14.3	61.3	3.10	7.57
Cuban Yellow Flint	278	58	0.89	13.8	50.7	4.44	8.14
Mean	251	55	0.92	14.3	57.9	3.34	7.57
LSD ..... at 0.05					16.7	1.11	1.95
at 0.01					22.6	1.50	2.64
HSD ..... at 0.05					31.9	2.12	3.70
at 0.01					37.6	2.49	4.36
				C.V. (%)	13.9	18.2	13.1

[a] Latitudes for the different states are approximates only.
[b] (A105 × A106) (A112 × A113).

ears per plant, and ear length. The hybrids are grouped according to State of origin and the States are arranged from North to South. The least significant difference (LSD) and honest significant differences (HSD) at the 0.05 and 0.01 levels are given for grain, stover, and fodder yields at the bottom of the table. Modern thinking in statistics favors the use of the HSD rather than the LSD when more than two entries are involved in a performance test. But the HSD (standard error of the mean x q) in some cases encountered by the senior writer seems so high that very few significant differences or none at all are observed even if the entry mean square was significant at the 0.01 level. Regardless of the LSD, however, the interest in this performance test was for a general idea of how U.S. double crosses from different parts in the U.S.A. performed in comparison with local high-yielding open-pollinated varieties in the Philippines . . . not whether this or that U.S. hybrid significantly outyielded this or that local variety or another U.S. hybrid.

In grain, stover, and fodder yields, the hybrids from North Carolina, Georgia, and Tennessee outperformed those from the other States. The effect of latitude was clearly illustrated here. Going south from Wisconsin to Iowa, there was a big increase in productivity. There was a continued increase, going further south from Iowa to Missouri, and from the latter to Tennessee. The hybrids from North Carolina and Georgia seemed slightly poorer than those from Tennessee in grain yield but were generally better in stover yield. The State of North Carolina lies east of Tennessee; the State of Georgia, southeast of Tennessee.

Federal hybrid US 523W was a high grain-yielder but a poor stover-yielder, so that the two Dixies, though slightly lower in grain yield, gave greater fodder yields. A similar situation existed between College Yellow Flint and Cuban Yellow Flint. The former is generally a better grain-yielder than the latter but the latter definitely produces more vegetative growth than the former.

With respect to fodder yield, there were several U.S. hybrids that showed signs of being better yielders than Cuban Yellow Flint. The fodder yields of the U.S. hybrids as compared to those of the local entries showed that they grew well during the season (1953-54 dry season) when they were grown.

One other character that could indicate relative "adaptability" was plant height. The tallest U.S. hybrids were taller than Cuban Yellow Flint. Four hybrids from Wisconsin, two from Iowa, one each from Missouri and Tennessee may be considered shorter than College Yellow Flint. The hybrids from North Carolina and Georgia were taller, on the average, than those from Tennessee but had lower grain yields. Thus, although high grain yields can generally be expected from tall corn, this observation suggests that taller corn does not necessarily produce more grains.

The U.S. hybrids silked earlier than they do in their respective places of origin in the U.S.A. The earliest entry silked 48 days after planting; the latest, 60, on the average. The Wisconsin hybrids silked 1 to 5 days earlier than College Yellow Flint (52 days); Missouri hybrids, 4 days later; Tennessee hybrids, 3 to 7 days later; North Carolina hybrids, 4 to 6 days later; and Georgia hybrids, 6 to 7 days later. One Iowa hybrid silked one day earlier than the College Yellow Flint; one, at the same time; and two silked one and two days later, respectively.

None of the entries gave a mean of more than one ear per plant. The local experimental hybrid gave the highest, 0.95 and the local entries gave the highest group mean of 0.92. There was an increase in mean number of good ears per plant going south from Wisconsin (0.60) to Georgia (0.86). North Carolina slightly ruined the trend because its mean number of good ears per plant (0.79) should have been higher than or equal to that of the Tennessee hybrids (0.85).

Most of the U.S. hybrids were attacked by earworms on account of their loose husks. Selection in the United States has been for loose husks, a characteristic that contributes to the ease in machine husking.

Missouri 804 and GCP 3129 had mean ear lengths of 17.5 and 17.3 centimeters, respectively. By local standards, these are long ears. These two and the rest of the U.S. hybrids in this test, however, give even longer ears when grown in their respective places of adaptation in the U.S.A. The Wisconsin hybrids, three of the four Iowa hybrids, and one Tennessee hybrid gave conspicuously short ears. The rest of the hybrids had ears that were slightly longer or as long as those of College Yellow Flint.

DISCUSSION AND CONCLUSION

The results of this one-season test showed that some U.S. hybrids tended to outperform College Yellow Flint, a high grain-yielder. But the direct regular use of the high-yielding U.S. yellow dent double crosses can not be recommended in the Philippines in the production of grain for use in livestock and poultry feeds. This season was relatively disease-free. It is expected that when diseases (downy mildew, rust, leaf blight, etc.) are prevalent, these U.S. hybrids will not do as well as College Yellow Flint which has undergone the process of natural selection for resistance to diseases that commonly occur under Philippine conditions.

It is, however, interesting to note that the U.S. hybrids, which have been developed under U.S. conditions, outyielded the long-established and high-yielding College Yellow Flint. The latitudes of the Philippines and of Tennessee, North Carolina, and Georgia are widely different. This could suggest that the College Yellow Flint germplasm, though productive enough, is not yet the best one that can be had for Philippine conditions. It is thus highly possible that some open-pollinated varieties from places with latitudes and altitudes

not very different from those obtaining in the Philippines can be obtained that will outyield College Yellow Flint and can be as dependable as the latter when it comes to resistance to the prevalent corn diseases in the Philippines.

The results of this study also indicate that in the absence of locally-developed standard hybrids and during shortages of local corn seeds, seeds of hybrids from Tennessee, North Carolina, and Georgia may be imported and used for planting in the Philippines.

THE ACID CONSTITUENTS OF SOME PHILIPPINE FRUITS [1]

A. R. Carangal, Jr., L. G. Gonzales, and I. L. Daguman

The acid content of six species of citrus fruits and 25 other fruits grown in the Philippines was determined by chromatographic analysis. Citric, malic, oxalic, iactic or succinic and formic, L-ketoglutaric or fumaric acids were found in them.

Citric acid was found in most of the fruits analyzed and was the predominant acid in the citrus fruits, *Antidesma bunius, Ananas comosus, Garcinia kydia, Sandoricum koetjape, Averrhoa bilimbi, Artocarpus rigida, Spondias mombin, Spondias dulcis, Calamus sp., Malpighia glabra,* and *Aglaia diffusa. Achras sapota, Diospyros discolor, Flacourtia ramontchi,* and *Annona muricata* had malic acid and *Averrhoa carambola* had oxalic acid as their predominant acid. The presence of acetic and lactic acids in some of the fruits is perhaps due to the deterioration of the fruit during the advanced ripening stage, except in *Psidium guajava* and *Tamarindus indica.*

The flavor of a fruit is dependent upon some chemical constituents, such as sugars and acids. The term "sugar-acid ratio" is used by pomologists as a measure of the apparent degree of sweetness of a fruit.

Investigations on the acidity of Philippine fruits have been conducted by Pratt and Del Rosario (1913)[2] and by Wells, Agcaoili, and Orosa (1925).[3] Pratt and del Rosario determined the major acid content of 26 species of fruits. Citric acid in Philippine citrus fruits was reported by Wells, *et al.* In these studies, only the predominantly occurring acids were determined by titration of water extract or juice of the samples. Also, chromatographic analysis was used to determine the nature and relative amounts of the different acids present in some Philippine fruits in this present work.

MATERIALS AND METHODS

Six species of citrus fruits and 25 other fruits were gathered from the trees grown in the U. P. College of Agriculture, except Calamus sp. which was bought in the local market. Most of the

[1] Central Experiment Station Contribution No. 2075.
[2] D. S. Pratt and J. F. del Rosario, *Phil. Jour. of Sci.* **8**, 59 (1913).
[3] A. H. Wells, F. Agcaoili, and M. Y. Orosa, *Phil. Jour. of Sci.* **28**, 453 (1925).

fruits, except those used as souring agents (*Tamarindus indica, Averrhoa balimbi, Psidium guajava*), were ripe. Aliquots of these juices were neutralized with 1.0 N NaOH and evaporated to dryness on a hot plate. Duplicate determination of total solids was carried out by drying to constant weight at 80°C. In some species, sliced fruits were dried in the oven at 80°C. for 12 to 24 hours, ground in the Wiley mill, and stored in a desiccator. Known weights of the dried samples were ground with 1 to 2 ml. of 4N H_2SO_4 and thoroughly mixed with silica gel. The mixture was then extracted with ether for 12 to 24 hours and the acids in the ether extract recovered as their sodium salt by washing with 0.1 N NaOH. The alkaline layer was separated from the ethereal layer and the former was evaporated to dryness. This ether extraction procedure was discontinued during the course of the work due to lack of water for the condenser. Instead, the dried sample was extracted with five times its weight with H_2O at 60-65°C. for 12 hours. The filtrate and washings were neutralized with NaOH and evaporated to dryness. This method of preparation may involve losses in volatile acid. At least four different samples of each specie were prepared for the subsequent chromatographic separation of the acid in the prepared extract.

The acids in the prepared extract were separated, following the column chromatographic method of Bulen, Varner and Burrell (1952).[4] No actual chemical identification of the separated acid was made, but were tentatively identified by their displacement volume using a standard chromatogram. The results presented in tables 1 and 2 are expressed in milliequivalent per gram of total solids of the juice or dried material.

RESULTS AND DISCUSSION

Citric acid was present in the highest amount followed by either malic acid or those of the lactic acid group (lactic and/or succinic acid) in the six species of citrus (table 1). Acetic and oxalic acids, the amounts of which are negligible if compared to citric and malic acids, were also found. *Citrus mitis* and *C. aurantifolia* had the highest level of citric acid in the juice. In these species and in *C. reticulata*, citric acid accounts for almost 90 to 95 per cent of the total acid. *C. grandis* had a much higher amount of lactic acid than the other citrus fruits.

[4] W. A. Bulen, J. E. Varner, and R. C. Burrell, *Analyt. Chem.* **24**, 187 (1952).

TABLE 1.—*Organic acids of some citrus fruits*

FRUIT	TRIAL	MEQ. OF ACID × 10^2/GRAM OF TOTAL SOLID					
		Acetic	Formic Group	Lactic Group	Oxalic	Malic	Citric
1. *Citrus aurantifolia* (Christm.) Swingle	1	*	—	*	—	22.0	882.3
	2	*	—	*	—	51.9	890.4
Lime, Dayap	3	*	—	2.5	—	37.5	996.4
	4	*	—	2.1	—	30.9	920.6
2. *Citrus grandis* (L) Osbeck	1	5.2	—	39.0	*	7.7	107.6
Suha, Pumelo	2	*	—	25.6	*	7.4	110.4
3. *Citrus hystrix* DC	1	—	—	—	—	6.0	241.2
Rough lemon	2	—	—	—	—	66.0	110.2
	3	—	—	—	—	26.7	214.5
	4	—	—	—	—	35.7	234.5
"Culubot"	1	—	—	—	—	*	339.5
	2	—	—	—	—	*	326.6
	3	—	—	—	—	5.3	382.6
	4	—	—	—	—	*	354.6
4. *Citrus mitis* Blanco	1	—	—	*	*	21.3	1057.9
Calamondin, Calamansi	2	—	—	*	*	*	1180.1
	3	—	—	3.6	*	10.3	1073.0
	4	—	—	4.1	*	14.5	1052.8
5. *Citrus paradisi* Macf.	1	—	—	—	—	23.1	275.0
Grapefruit, Pumelo	2	—	—	—	—	68.6	138.7
	3	—	—	—	—	27.5	261.2
	4	—	—	—	—	37.5	244.4
6. *Citrus reticulata* Blco.	1	—	—	—	—	*	187.9
Batangas mandarin	2	—	—	—	—	*	214.4
	3	—	—	—	—	*	239.2
	4	—	—	—	—	*	213.7
Szinkom variety	1	—	—	—	—	20.5	375.1
	2	—	—	—	—	28.2	119.3
	3	—	—	—	—	14.5	207.4
	4	—	—	—	—	19.0	283.9

* Trace.

Citric acid was also present in all the other species analyzed except in *Flacourtia ramontchi* and *Lucuma nervosa* (table 2). *Ananas comosus, Antidesma bunius* and *Averrhoa bilimbi, Garcinia kydia, Sandoricum koetjape* (rind), and *Aglaia diffusa* have citric acid in their juice comparable in amount to that in citrus fruits. Citric acid was also present in the highest amount in the juice of *Anona squamosa, Mangifera indica* (Cambodian and Indian mangoes), *Sandoricum koetjape* (pulp), *Spondias purpurea, Persia*

americana, Spondias mombin, Spondias dulcis, Psidium guajava, Calamus sp., and *Malphighia glabra.*

TABLE 2.—*Organic acids of some Philippine fruits*

FRUIT	TRIAL	MEQ. OF ACID × 10^2/GRAM OF TOTAL SOLID					
		Acetic	Formic Group	Lactic Group	Oxalic	Malic	Citric
1. *Achras zapota* L.	1	**	1.9	—	1.9	5.0	3.3
Sapodilla, Chico	2	2.6	1.7	—	1.6	11.5	2.6
	3	2.3	2.2	—	1.2	12.5	2.6
	4	2.9	1.1	—	1.4	9.4	2.8
2. *Ananas comosus* (L)	1	—	—	—	—	1.3	138.0
Merr.	2	—	—	—	—	1.9	151.8
3. *Anona squamosa* L.	1	1.2	**	0.7	**	9.4	16.8
Sweetsop, Atis	2	0.3	**	0.5	**	9.9	11.0
4. *Anona muricata* L.	*	4.1	1.4	2.6	0.6	4.4	1.3
Soursop, Guayabano		3.3	1.4	2.8	0.6	5.9	1.5
5. *Antidesma bunius* (L)	1	—	—	**	—	4.8	958.2
Spreng	2	—	—	**	—	7.7	1010.8
Bignay							
6. *Artocarpus communis*	1	1.6	1.1	3.1	2.1	3.0	6.1
Forst	2	1.5	1.2	3.3	2.2	2.9	6.5
Rimas, Breadfruit							
7. *Artocarpus rigida*	1	—	—	—	—	25.9	139.1
Caringing	2	—	—	—	—	23.3	131.3
8. *Averrhoa carambola* L.	1	—	—	1.3	61.7	38.9	**
Sweet balimbing	2	—	—	**	29.1	34.0	5.6
	3	—	—	2.9	43.5	27.7	8.5
	4	—	—	3.2	64.4	36.3	7.9
Sour balimbing	*	1.9	—	1.5	223.1	***	
		3.4	—	7.8	181.5	2.5	**
	3	3.0	—	1.6	174.1	3.0	1.1
	4	1.4	—	2.8	312.2	1.9	0.8
9. *Averrhoa bilimbi* L.	1	1.6	0.6	0.6	8.9	**	94.8
Camias	2	1.6	0.4	1.2	8.6	—	115.4
	*	1.9	0.9	1.0	5.5	**	133.8
		1.7	**	0.4	7.8	**	92.6
10. *Calamus* sp.	*	2.1	1.8	2.1	0.4	17.6	31.8
		0.7	0.5	2.6	**	16.5	29.2
11. *Diospyros discolor*	1	**	—	**	2.1	8.9	6.4
Willd.	2	**	—	2.1	1.4	7.9	5.9
Mabolo							
12. *Diospyros ebenaster*	1	2.1	1.4	1.5	1.1	—	1.2
Retz.	2	1.9	2.0	3.4	1.3	—	1.2
Sapote							

* Ether extract.
** Trace.
*** Discontinued.

TABLE 2 (continued)

FRUIT	TRIAL	MEQ. OF ACID × 10^2/GRAM OF TOTAL SOLID					
		Acetic	Formic Group	Lactic Group	Oxalic	Malic	Citric
13. *Flacourtia ramontchi*	1	1.0	—	—	—	4.4	—
L'Herit	2	1.5	—	—	—	6.1	—
Governor's Plum	3	—	—	—	—	—	—
14. *Garcinia kydia*	1	—	—	—	—	28.8	198.7
Kydia	2	—	—	—	—	22.2	316.1
15. *Lucuna nervosa* ADC	1	2.1	3.4	2.9	1.9	3.3	—
Ti-esa	2	2.2	2.4	2.0	1.4	2.8	—
16. *Malpighia glabra* L.	1	2.3	1.5	3.7	6.2	1.5	59.1
Malpighia	2	1.2	2.4	2.1	5.4	1.8	56.7
17. *Mangifera indica* L.	1	**	—	0.3	—	1.3	16.4
Cambodian mango	2	**	—	0.4	—	1.5	16.7
	1	0.3	—	0.7	**	1.3	42.6
18. *Persea americana* Mill.	1	2.2	3.5	—	1.2	3.1	5.3
Avocado	2	1.4	1.3	—	1.4	3.2	6.0
19. *Psidium guajava* L.	1	3.5	**	6.7	1.6	6.8	26.5
Guava	2	2.3	**	4.5	0.6	2.9	44.8
	3	3.3	**	7.3	0.9	6.7	28.3
	4	3.0	**	6.9	0.9	6.6	39.0
20. *Sandoricum koetjape*	1	—	**	**	—	1.7	128.7
(Burm. f.) Merr.	2	—	**	**	—	4.4	132.7
Santol rind							
Santol pulp (seed covering)	1	—	—	**	—	1.2	16.4
	2	—	—	**	—	1.0	22.4
21. *Spondias dulcis*	*	1.3	—	—	—	**	33.4
Forst. f.		1.3	—	—	—	0.25	29.4
22. *Spondias mombin* L.	1	1.9	—	—	—	—	30.6
(Syn. *Spondias lutea* L.)	2	1.9	—	—	—	—	28.7
23. *Spondias purpurea* L.	1	—	—	**	—	0.9	40.8
Siniguelas	2	—	—	**	—	—	45.6
24. *Tamarindus indica* L.	1	1.6	**	1.2	—	5.3	14.8
Sampaloc	2	3.5	**	1.5	—	2.4	8.0
	3	2.7	**	1.3	—	4.3	12.8
	4	2.3	**	1.2	—	4.8	11.1
25. *Aglaia diffusa* Merr.	1	1.5	—	2.5	—	—	141.1
	2	1.9	—	4.4	—	—	159.1

* Ether extract.
** Trace.

Malic acid was the predominant acid in *Diospyros discolor*, *Achras zapota*, and *Flacourtia ramontchi*. Considerable amounts of acetic acid (relative to other acids) were found in *Psidium guajava* and *Tamarindus indica*. The occurrence of acetic and lactic acids

in other fruits probably results from the deterioration of the fruits during the stage of advanced ripening.

Averrhoa carambola, especially the sour variety, had the highest amount of oxalic acid; this is the predominant acid in this specie Although *Averrhoa bilimbi* belongs to the Oxalidacease family, it had a very low oxalic acid content, but had citric acid as its major acid. The high amount of oxalic acid in *A. carambola* should be considered in its nutritive quality.

The levels of the acid found in the different fruits showed a wide range of variability (tables 1 and 2). These wide variations in amount are presumably due to differences in the stage of ripening of the fruit. Acidity of fruits undergoes changes during the development and ripening of fruits.

THE OCCURRENCE OF TWIN EMBRYOS IN *COCOS NUCIFERA* L.[1]

VIRGILIO F. GUEVARA

Twin embryos, which have not emerged from the germinating eye in the fruit of *Cocos nucifera* Linn., were discovered by the writer while examining 100 embryos excised from a pile of seednuts being prepared for copra-making in Barrio San Andres, Alaminos, Laguna, on November 26, 1960. The embryos are shown in figure 1.

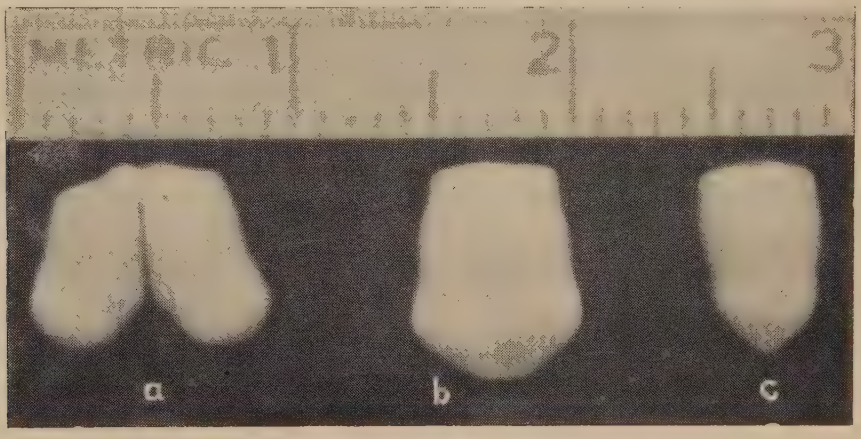

Fig. 1.—Twin embryos *a* and *b;* normal embryo *c* of *Cocos nucifera* L.

All the embryos were still embedded in the solid endosperm directly beneath the fertile eye at the time of excision, indicating that they will most likely emerge from these points upon future development. The development of more than one shoot in the seed of the coconut palm was reported earlier by other workers. Costerus and Smith (1923) and Furtado (1926-1929) reported cases where three distinct shoots emerged through the fertile eye. The individual shoots, on splitting of the seednuts, were found to originate from separate embryos each with a haustorium of its own. Quisumbing (1926) reported three nuts with two, three, and five shoots. Viewed externally, the individual shoots seemed to have emerged separately from two and three eyes in the seednut, hence, Quisumbing stated that the

[1] Central Experiment Station Contribution No. 2076.

shoots in these cases developed from two and three functional ovules. He was, however, unable to account for the extra shoots in the case of the seednuts with five shoots because as in the former two, the material was not placed at his disposal for dissection. Davis *et al.* (1923), as cited by Menon and Pandalai (1958), "described in detail instances of polyembryony" but unfortunately, the writers did not have access to the original publication. Menon and Pandalai (1958) stated that the occurrence and emergence of more than one shoot (i.e., two or three) through a single eye is rare in this plant. It is apparent from the foregoing review that the previously reported polyembryonic cases were based on observations made on the seedling stages.

The materials under report seem to be two different cases of twining. As seen in figure 1(a), the two embryos approximate one another and are closely appressed at their distal or upper ends but are separated at their proximal or haustorial ends at a 60 degree angle assuming an inverted V-like appearance. The embryos were slightly set apart from one another in the photograph to indicate the extent of their appressed surfaces. When the surrounding endosperm tissue was removed, the embryos readily separated from one another at their point of contact without any trace of broken tissue, indicating that they are entirely free from each other and are held together only by the surrounding endosperm. In *b*, the embryos are completely joined throughout their length and did not separate when excised from the endosperm tissue. A shallow ridge approximately one mm. in depth runs along the median region on two surfaces at their point of union. The ridge is more prominent on one side towards the haustorial end of the embryos. All the embryos shown in figure 1 are apparently of the same stage of development as indicated by their sizes. The normal embryo (c) is more or less cylindrical in form with a slight constriction or neck (not clear in the figure) between the distal and proximal ends, the latter being about one-third of the whole length of the embryo, and tapering gradually to a point towards its proximal tip. The distal end shows the presence of a pigmented area about one mm. in diameter at the central portion with a slight bulge towards one side. Aside from the constriction between them, the upper and lower sections are distinguishable from each other in that the upper end is white and smooth-surfaced, while the lower end is slightly yellowish and is characterized by the presence of fine shallow grooves running parallel to the longitudinal axis. All these above-mentioned external features are evi-

dent in the twin embryos. The only morphological difference between them and the normal is the deformity caused by the adherence of the twins to each other, and the greater size of the pigmented region, they being actually made up of two coalesced areas.

The current observation substantiates those made on the seedling stages. The writer is presently not in a position to advance satisfactory explanation that could account with certainty the possible causes of the observed phenomenon in the embryo labeled *b* in the figure. However, on the basis of the close proximity of the twin embryos labeled *a* in the figure and their position in the seed nuts, the extra embryo may have been most likely derived from synergids. Weber (1940) cited the reports on such cases of Kajale (1937) in *Boerhaavia* (Nyctaginaceae) and Dutt and Shubba Rao (1933) and Dutt and Krishnaswami (1932) in *Saccharum* (Gramineae). Or it may be a result of separation of the zygote into two units each developing into separate embryos. Weber (1940) states that cleavage polyembryony is comparatively rare in angiosperms, having been reported only in a few genera such as *Loranthus, Erythronium, Tulipa* and *Limnocharis* (Ernst, 1918) and *Lobelia* (Crete, 1938).

Preparation of serial sections of these embryos for anatomical observations is underway and results will be reported in a future paper.

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NOTE: WILD SPECIES OF RICE IN THE PHILIPPINES

About a quarter of a century ago, one species of wild rice was reported occurring in the Philippines (Capinpin, 1938).[1] This wild type was the *Oryza minuta,* a tetraploid with 48 chromosomes, unlike the cultivated rice, *Oryza sativa,* a diploid which had 24 chromosomes. The plant breeding value of this wild type was subsequently determined (Capinpin and Magnaye, 1951).[2]

Recently, the junior author together with a rice geneticist from Japan, Tadao Katayama, through the efforts of Dr. H. Kihara, Director of the National Institute of Genetics, Japan, and member of the Board of Trustees of the International Rice Research Institute at Los Baños, Laguna, Philippines, undertook botanical trips in different regions of the Philippines to collect various species of wild rice and determine the regions hitherto unchartered in the phytogeographical center of distribution of the genus *Oryza.* This botanical exploration which covered the regions of Luzon, Visayas, and Mindanao, resulted in the discovery of five additional wild species unreported in the Philippines. *Oryza minuta* was also collected.

The wild species of rice and the localities where they have been collected during this trip are as follows:

1. *Oryza minuta* Presl. (Zamboanga, Negros Occidental, Bohol, and Sorsogon)
2. *O. perennis* Moench. (Musuan, Bukidnon)
3. *O. granulata* Nees et Arn. ex Hook. f. (Palawan)
4. *O. meyeriana* (Zoll. et Mor.) Baill. (= *O. abromeitiana* Prod.) Negros Occidental)
5. *O. sativa* L. var. *spontanea* Roschev. (Cawayan, Isabela)
6. *O. officinalis* Wall. ex Watt. (Zamboanga)

One of the interesting findings is the existence of *O. perennis,* a floating rice, attaining a height of seven feet and the panicles of which may be the only part of the plant that could be casually observed on the water surface. This may be a distinct biotype of *O. sativa,* a floating rice from Assam which Dr. Kihara sent to the

[1] J. M. Capinpin, *Nat. Res. Coun. of the Phil. Bull.* **16**, 37 (1938).
[2] J. M. Capinpin and A. B. Magnaye, *The Philippine Agriculturist,* **34**, 219 (1951).

Department of Agricultural Botany for trial planting and comparison with the Philippine type of floating rice.

Specimens of the above wild species of *Oryza* are now in the collection of the Department of Agricultural Botany, U.P. College of Agriculture. They are now the subject of cytogenetic studies and genomic characteristics and also of world genetic stock studies of rice. Reports on the results of these studies will be forthcoming.

J. M. Capinpin and J. V. Pancho

MONTGOMERY E. ROBINSON *

WHEREAS, in the death of Montgomery E. Robinson the agricultural profession lost an outstanding administrator, an effective leader, an inspiring teacher and a gentleman; and

WHEREAS, he did invaluable work with subject-matter staff in coordinating extension programs and dealing with the interrelationships between research, resident instruction and extension teaching; and

WHEREAS, he laid the foundation, as first Cornell project leader, of the singularly successful Cornell-Los Baños contract which contributed greatly to the rehabilitation of the College of Agriculture; and

WHEREAS, he was instrumental in the introduction of extension courses in the College of Agriculture, thereby leading to the institution of extension work as a major subject; now therefore be it

RESOLVED, that the faculty of the College of Agriculture of the University of the Philippines, hereby express its feeling of grievous loss and extend to his widow and children its deepest sympathy; and be it further

RESOLVED, that this resolution be recorded in the minutes of the faculty of the College of Agriculture and copies sent to the archives of the University and that it be published in *The Philippine Agriculturist*.

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* Resolution passed by the faculty of the College of Agriculture, University of the Philippines, on January 21, 1961.

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